

Critical Item List

Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000

Functional Assy: Pump Section 01

Prepared by: D.F. Clark

Approved by: A.J. Slone

CIL Item: 0102

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Issue Date: October 28, 1986

Rev. Date: April 16, 2001

CIL Item Code: 0102
 FMEA Item Code: 0102
 Function: Direct pump flow
 Subsystem\Item No.\Part No.: HPFTP/AT\B300\4700000

Analyst: D.F. Clark
 Approved by: A.J. Slone
 Rev. No.:
 Rev. Date: April 16, 2001
 Effectivity:
 Hazard Ref.: See Listings Below

Operating Phase	Failure Mode, Description and Effect	Criticality
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Operating Phase:

s,m

Failure Mode:

Failure to direct flow into the first impeller causing loss of impeller head rise.

Failure Cause(s)

- A. f/n 091 Fracture, erosion or distortion of the inlet vane in the inlet housing due to vibration, contamination, cavitation, or material/mfg. defect.
- B. f/n 060, 061 & 100 Fracture or erosion of the diffusers or failure of the diffuser nut due to vibration, contamination, or material/mfg. defect.
- C. f/n 106 Fracture, erosion or distortion of the exit vanes in the Discharge Housing due to excessive load, contamination, or material/mfg. defect.

Failure Effect:

Leakage from the flow path would decrease pump output pressure. Reduced pump output would be sensed by the controller which increases fuel preburner oxidizer flow. Excessive turbine discharge temperature will cause a redline shutdown.

System:

Engine shutdown

Mission/Vehicle:

Mission scub/abort.
 Loss of vehicle due to HPFTP turbine failure may result if not detected.

Redundancy Screens:

- A: Pass. Redundant hardware items are capable of checkout during normal ground turnaround.
- B: Pass. Loss of a redundant hardware item is detectable during flight
- C: Pass. Loss of redundant hardware items could not result from a single credible event.

Criticality:

1R

Hazard Ref:

- A) D1S/A/M/C (AT): 1B2.1.2.1.1.1.1, 1B2.1.2.1.1.1.2, 1B2.1.2.1.1.4, 1B2.1.2.1.1.5
- B) D1S/A/M/C (AT): 1B2.1.2.1.1.1.1, 1B2.1.2.1.1.1.2, 1B2.1.2.1.1.3, 1B2.1.2.1.1.4, 1B2.1.2.1.1.5
- C) D1S/A/M/C (AT): 1B2.1.2.1.1.3, 1B2.1.2.1.1.4, 1B2.1.2.1.1.5

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Find Number Find Name	Design Considerations
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f/n 091

Inlet Vane

FAILURE CAUSE A: Fracture, erosion or distortion of the inlet vane in the inlet housing due to vibration, contamination, cavitation, or material/mfg. defect.

The Pump Inlet Housing (PIH, FN 091) provides the volute and guide vanes for directing fuel flow to the 1st Stage Impeller. The PIH is an inseparable assembly of two castings and a pinned-in labyrinth seal holder. One casting consists of the volute and housing section (FN 091-01), and the second casting is a ring-strut-ring (FN 091-02) that contains the guide vanes. The castings, made of INCO 718 per Spec PWA-SP 1490 for its' cryogenic strength, toughness and weldability, are brazed in two locations: The pump end braze of the Vane Ring serves as a structural joint, and carries in shear the axial loads through the Vane Ring. The turbine-end braze at the Retention Hook feature of the castings is a manufacturing braze. It insures that the Retention Hook seat is maintained throughout all post-braze turning and drilling processes. The seal holder (FN 091-05) is installed and loaded with a work nut axially prior to pinning (FN 091-06) and serves as a redundant axial constraint for the Vane Ring.

The vanes (FN 091-02) are fracture critical parts and meet all the requirements of the SSME ATD fracture control plan FR-19793-5.

DVS 4.1.2.3 Pump hydrodynamics analysis to verify pump performance is complete. The results are documented in FR-20709-01 and -02 with the VCR in FR-20712-27 and FR-23231-107.

f/n 060, 061, 100

Diffusr 1, 2, invrt. Nut

FAILURE CAUSE B: Fracture or erosion of the diffusers or failure of the diffuser nut due to vibration, contamination, or material/mfg. defect.

The Interstage Diffusers (FN's 060 & 061) provide the primary flowpaths between impellers via 13 cross-over ducts very similar to the Rocketdyne HPFTP. Pencil cores were incorporated to recirculate leakage flow back to the 1st and 2nd impeller inlets and to improve thrust balance capability. The diffusers are cast A357 Aluminum per AMS 4219 for its' strength and there are lightening cores for weight savings.

The 1-2 Interstage Diffuser assembly consists of two dowel pins which engage the 2-3 Interstage Diffuser for alignment and torque transfer, three sets of 13 inserts for knife edge and damping seal retaining screws and one set of 13 inserts for tooling. The diffuser detail incorporates 13 - 1st impeller back face vanes for improved thrust balance capability. Pilot diameters, transfer tube holes and knife edge flow impingement areas are hard faced to reduce fretting, galling and erosion.

The 2-3 Interstage Diffuser assembly consists of a spacer which provides a bearing surface for the retaining nut, three sets of 13 inserts for knife edge and damping seal retaining screws and one set of 26 inserts for tooling. The Diffuser detail incorporates 13 - 2nd impeller back face vanes and 13 - 3rd impeller front face vanes for improved thrust balance capability. It also has 2 O.D. slots for alignment to the Discharge Housing and carrying torque load from both diffusers. Pilot diameters, transfer tube holes and knife edge flow impingement areas are hard faced to reduce fretting, galling, and erosion.

The 1-2 Diffuser Shim (FN 068) is classed to maintain a tightly controlled assembly gap. During operation, the 1-2 Diffuser is loaded axially through the shim into the Inlet Housing.

The 2-3 Diffuser axial load is taken out through the inverted nut (FN 100) into the Discharge Housing. This prevents the total diffuser load from having to be carried through the 1-2 Diffuser. The tall radial height and steep face of the thread was required to retain the high assembly load. The nut is axially loaded at assembly by applying hydraulic ram load to the diffuser and tightening the nut to maintain diffuser compression. Load on the nut becomes less during operation. A sufficient margin of safety in thread shear is maintained at all times. A dowel pin (FN 322) installed in the 1-2 Diffuser serves to lock the nut.

Thirteen transfer tubes (FN 063) carry the pencil core flows between diffusers.

The diffusers are fracture critical parts and meet all the requirements of the SSME ATD fracture control plan FR-19793-5.

DVS 4.1.3.2.1 Water flow visualization and pressure measurement model tests are complete. The results are documented in FR-19848-3 and FR-20599 with the VCR in FR-20712-27 and FR-23231-107.

f/n 106

Exit Vanes

FAILURE CAUSE C: Fracture, erosion or distortion of the exit vanes in the Discharge Housing due to excessive load, contamination, or material/mfg. defect.

The HPFTP discharge housing (FN 106) is a hot isostatically pressed INCO 718 investment casting. This material is used for its' cryogenic strength and toughness. It contains the flow path geometry for the exiting fuel, and provides a primary structural support for the overall assembly. It is one of the three primary structural elements and is fastened between the inlet housing at the pump end and the turbine housing at the turbine end. The discharge housing also referred to as the main housing provides the exit flow path from the third and final impeller to the collecting duct on the main engine. Internally, the housing supports the third impeller pump side tip seal and the 2-3 diffuser and provides anti-rotation for the latter. The flow path itself contains ten short airfoil shaped vanes and two flow splitters directing flow from the third impeller into the collecting volute. The splitters cover a much longer circumferential arc than do the vanes, and exist as structural ribs preventing excessive load through the smaller vanes. All vanes and the leading part of the flow splitters receive a shot peen and the housing receives a proof pressure test.

The vanes are fracture critical and meet all the requirements of the SSME ATD fracture control plan FR-19793-5.

DVS 4.1.4.4.1.5 Duty cycle and LCF life capabilities of the pump discharge housing and exit vanes are being verified during engine testing at SSC. The results will be included in the engine testing VCR FR-20904-500 and -501

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Inspection and Test

Possible Causes	Significant Characteristics	Inspection and Test	Document Ref
Failure Cause A f/n 091 Housing Asyo,Pump In	Material Integrity	Material integrity of bearing support casting (f/n 091-02-1) is verified per specification requirements	PWA-SP 1490-1
		Material integrity of housing (f/n 091) is verified per specification requirements	PWA-SP 1146
		Welding integrity of core supports closures on housing casting (f/n 091-01-1) are verified per drawing and specification requirements	PWA-SP 36158
		Chrome plating integrity of housing A/O (f/n 091) is verified per specification requirements	AMS 2406
		Material integrity, heat treatment and hardness of insert (f/n 091-04) are verified per drawing and specification requirements	AMS 5662 & PWA-SP 11-17
		Weld repair integrity of bearing support casting (f/n 091-02-1) is verified per specification requirement	PWA-SP 36158
		Material integrity of stud (f/n 091-03) is verified per specification requirement	PWA-SP 115
		Heat treatment and hardness of housing A/O (f/n 091) is verified per specification & drawing requirements	PWA-SP 11-17, PWA-SP 1490
		Braze integrity of housing A/O (f/n 091) is verified per drawing and specification requirements	PWA-SP 19 & AMS 4786
		Material integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 1490-1
		Weld repair integrity of housing casting (f/n 091-01-1) is verified per specification requirements	PWA-SP 36158
	Inspection	Ball bearing journal diameter (f/n 091) is verified per drawing requirements	
		Wall thicknesses on housing A/O (f/n 091) (2 places) are verified per drawing requirement	
	Finished Material	Proof pressure test of housing A/O (f/n 091) is verified per specification requirements	REI 017
		FPI- per- QAD (stud) (f/n 091-03)	SP-FPM Master

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		FPI- per- QAD (housing A/O) (f/n 091)	SP-FPM Master	
		FPI- per- QAD (housing) (f/n 091-01)	SP-FPM Master	
		Sonic- per- QAD (housing A/O) (f/n 091)	SP-SIM 309	
		Xray- per- QAD (housing casting) (f/n 091-01-1)	SP-XRM Master	
		Xray- per- QAD (bearing support casting) (f/n 091-02-1)	SP-XRM Master	
	Assembly Integrity	Inspection of F3 Pump Inlet Flange interface seal surface finish is verified per REI	REI 012	
	Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master	
Failure Cause B f/n 060 Diffuser Assy,Stg 1	Material Integrity	Hip of casting (f/n 060-02-1) is verified per drawing requirements		
		Heat treatment of casting (f/n 060-02-1) is verified per specification requirements	PWA-SP 11-32	
		Material integrity of casting (f/n 060-02-1) is verified per specification requirements	AMS 4219	
		Material integrity of pin (f/n 060-04) is verified per specification requirement	AMS 5735 per MS9390B	
			Material integrity of insert (f/n 060-01) is verified per specification requirements	AS 7245 per MS21209/MIL-I-8846
	Raw Material	Xray- per- QAD (casting) (f/n 060-02-1)	SP-XRM Master	
	Finished Material	Xray- per- QAD (A/O) (f/n 060)	SP-XRM Master	
		FPI- per- QAD (A/O) (f/n 060)	SP-FPM Master	
		Proof pressure test of A/O (f/n 060) is verified per specification requirements	REI 017	
	Assembly Integrity	Part seating is verified per REI	REI 012	
Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master		

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Possible Causes	Significant Characteristics	Inspection and Test	Document Ref	
Failure Cause B f/n 061 Diffuser Assy,Stg 2	Material Integrity	Hip of casting (f/n 061-03-1) is verified per drawing requirements		
		Heat treatment of casting (f/n 061-03-1) is verified per specification requirements	PWA-SP 11-32	
		Material integrity of casting (f/n 061-03-1) is verified per specification requirements	AMS 4219	
		Material integrity of insert (f/n 061-01) is verified per specification requirements	AS 7245 per MS21209/MIL-I-8846	
		Raw Material	Xray- per- QAD (casting) (f/n 061-03-1)	SP-XRM Master
		Finished Material	FPI-per-QAD (f/n 061 prior to assy. of spacer)	SP-FPM Master
			Xray- per- QAD (A/O) (f/n 061)	SP-XRM Master
			FPI- per- QAD (A/O) (f/n 061)	SP-FPM Master
			Proof pressure test of A/O (f/n 061) is verified per specification requirements	REI 017
		Assembly Integrity	Part Seating of DIM S6.2 is verified per REI	REI 012
Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master		
Failure Cause B f/n 100 Invr Nut,Stg.2,Diffu	Material Integrity	Material integrity and heat treatment are verified per drawing and specification requirements	AMS 5664	
		Finished Material	FPI- per- QAD	SP-FPM Master
		Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
Failure Cause b f/n 063 Tube,Transfer	Material Integrity	Material integrity is verified per specification requirements	AMS 5732	
Failure Cause b f/n 068 Shim,Diffuser	Assembly Integrity	Selection of classification of part is verified per assembly drawing requirements		

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Possible Causes	Significant Characteristics	Inspection and Test	Document Ref	
Failure Cause b f/n 322 Pin,Fwd.Diffuser	Material Integrity	Material integrity is verified per specification requirements	AMS 5735 per MS9390	
		Material integrity of casting (f/n 106-03-1) is verified per specification requirements	PWA-SP 1490-2	
Failure Cause C f/n 106 Housing Assy,Dischrg	Raw Material	Shot peen of housing (f/n 106-03) is verified per specification requirements	AMS 2430	
		Weld repair integrity (to vanes and splitters on casting) (f/n 106-03-1) is verified per specification requirement	PWA-SP 36158	
		Xray- per- QAD (casting) (f/n 106-03-1)	SP-XRM Master	
		FPI- per- QAD (casting) (f/n 106-03-1)	SP-FPM Master	
		Finished Material	Proof pressure test of A/O (f/n 106) is verified per specification requirements	REI 017
			FPI- per- QAD (A/O) (f/n 106)	SP-FPM Master
		Assembly Integrity	Part Seating of DIM S1.1 is verified per REI	REI 012
			Inspection of F4 Pump Discharge Flange interface seal surface finish is verified per REI	REI 012
		Recycled Hardware	FPI- per- PWA-SP 36187	PWA-SP 36187 & SP-FPM Master
		All Cause	Assembly Integrity	Shipping container; cleanliness control of closures, desiccant material and GN2 purge are verified per specification requirements
Cleanliness control of all parts during final assembly are verified per specification requirement	PWA-SP 80			
	Acceptance	Acceptance test will be conducted as required by contract, to demonstrate specified performance.	FR24542	